

APPENDIX 8-I. LIFE-CYCLE COST ANALYSIS FOR SMALL AND LARGE VOLUME GAS-FIRED AND ELECTRIC STORAGE WATER HEATERS

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8-I.1 INTRODUCTION

As explained in chapter 10, DOE wanted to consider a pairing of efficiency levels that will promote the penetration of advanced technologies into the electric and gas-fired storage water heater markets and potentially save additional energy. Consequently, DOE is pairing an efficiency level requiring heat pump technology for large-volume electric storage water heaters with an efficiency level achievable using electric resistance technology for small-volume electric storage water heaters. In addition, DOE is pairing an efficiency level requiring condensing technology for large-volume gas storage water heaters with an efficiency level that can be achieved in atmospherically-vented gas-fired storage water heaters with increased insulation thickness for small storage volumes.

TSL 5 includes efficiency levels that require heat pump technology for electric storage water heaters with rated storage volumes at and above 56 gallons, and efficiency levels that require condensing technology for gas-fired storage water heaters with rated storage volumes at and above 56 gallons. Based on its market assessment, DOE estimated approximately 4 percent of gas-fired storage water heater shipments and 11 percent of models would be subject to the large-volume water heater requirements using the TSL 5 and 6 division. Similarly, DOE estimated approximately 9 percent of electric storage water heater shipments and 27 percent of models would be subject to the large volume water heater requirements using the TSL 5 and 6 division.

To derive the life-cycle cost (LCC) and payback period (PBP) results for TSL 5, DOE divided the results for gas and electric water heaters into two groups, one consisting of households with small-volume water heaters, and the other consisting of households with large-volume water heaters.

8-I.2 INPUTS TO LCC AND PBP ANALYSIS

DOE divided the gas and electric storage water heater subsets (see chapter 7 for description) into two further subsets designed to include households that use either small-volume or large-volume water heaters using RECS 2001 and 2005.^{1, 2} Table 8-I.2.1 and Table 8-I.2.2 show the details of the assignment of sample households to these two subgroups. Note that some households fall into both samples. For these households, their weights are divided appropriately based on Table 8-I.2.2 so that the total number of households in the national sample and “small-volume” plus “large-volume” is the same.

Table 8-I.2.1 Selection of RECS 2005 Records for Water Heaters

Product Class	Algorithm	Sample	No. of Records	No. of U.S. Households Represented (million)
Natural Gas and LPG Storage	Storage Water Heater = Yes Fuel Type = Natural Gas or LPG Shared Water Heater = No	Small-Volume	2166	53.1
		Large-Volume	144	2.1
Electric Storage	Storage Water Heater = Yes Fuel Type = Electricity Shared Water Heater = No	Small-Volume	1465	35.9
		Large-Volume	261	3.6

Table 8-I.2.2 Water Heater Tank Sizes Selected for Sample Households

Fuel Type	RECS Size Class	No. of Bathrooms	Water Heater Tank Size (gal)	Percent Assigned to Size Class	Subset
Natural Gas or LPG	Small	Any # BR	30	100%	Small-Volume
	Medium	Any # BR	40	77.9%	
			50	22.1%	
	Large	2 BR	50	100%	
		≥ 3 BR	50	45.5%	Large-Volume
			65	27.2%	
Electric	Medium	Any # BR	75	27.2%	Large-Volume
	Large	< 2 BR	50	100%	Small-Volume
			50	64.6%	
		2 BR	65	24.6%	
			80	10.8%	
		≥ 3 BR	80	65.3%	Large-Volume
			119	34.7%	

Figure 8-I.2.1 and Figure 8-I.2.2 show the range in hot water use among sample households in each subgroup. The households with large-volume water heaters have higher median hot water use.

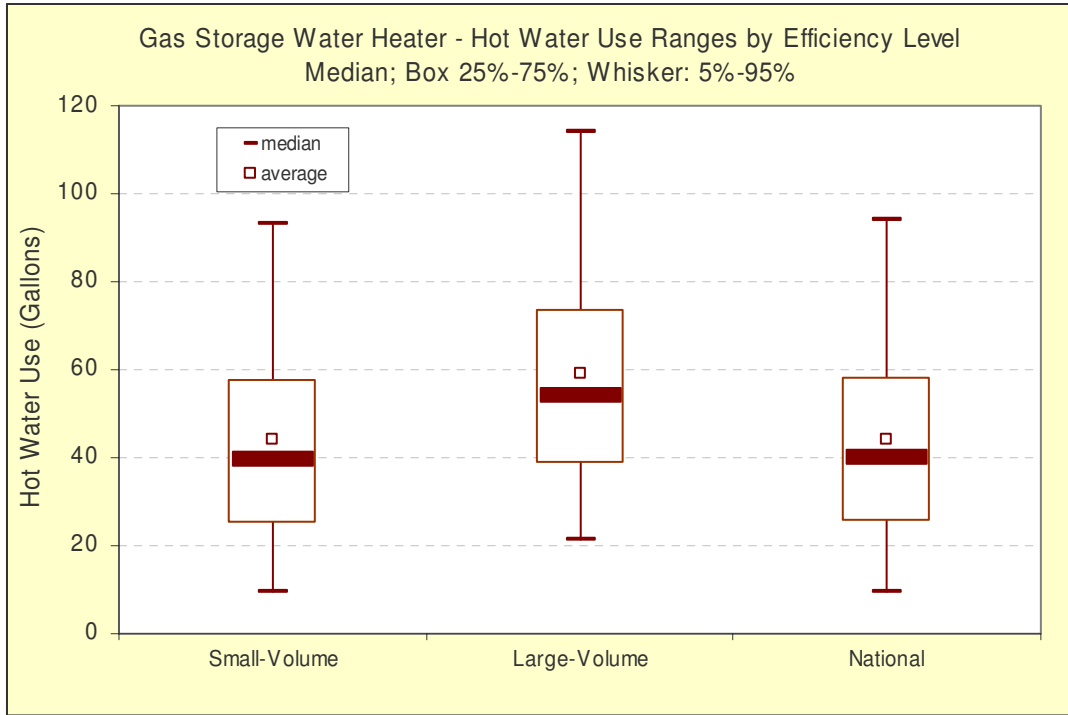


Figure 8-I.2.2 Range of Daily Hot Water Use in Sample Households for Gas Storage Water Heaters

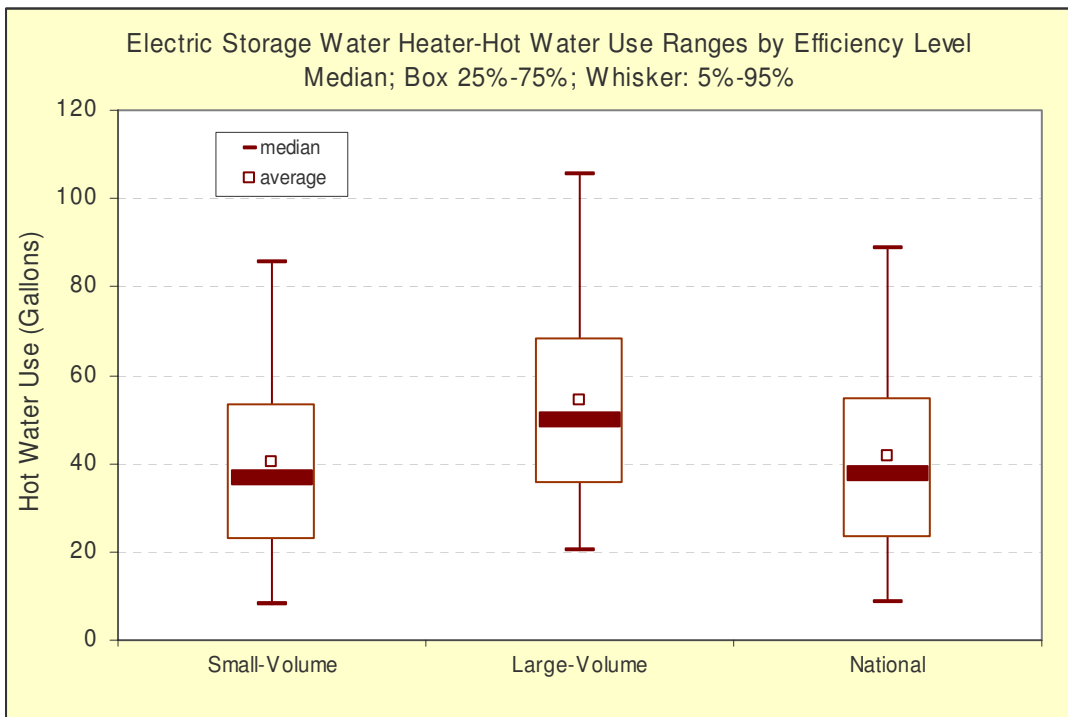


Figure 8-I.2.3 Range of Daily Hot Water Use in Sample Households for Electric Storage Water Heaters

Table 8-I.2.3 lists the average annual energy use for gas-fired storage water heaters in each subgroup.

Table 8-I.2.3 Annual Energy Consumption for Gas-Fired Storage Water Heaters

Energy Efficiency Level (EF)	Average Energy Consumption					
	Small-Volume		Large-Volume		All	
	Gas (MMBtu/yr)	Electricity (kWh/yr)	Gas (MMBtu/yr)	Electricity (kWh/yr)	Gas (MMBtu/yr)	Electricity (kWh/yr)
0.59 (baseline)	16.3	0	22.2	0	16.7	0
0.62	15.5	0	21.0	0	15.9	0
0.63	15.0	6	20.6	6	15.5	0
0.64	14.5	69	19.6	63	14.8	83
0.65	14.1	67	18.9	62	14.5	82
0.67	13.5	66	18.4	61	14.0	80
0.77	11.8	61	15.7	56	12.2	73

Table 8-I.2.4 lists average annual energy use for electric storage water heaters in each subgroup.

Table 8-I.2.4 Annual Energy Consumption for Electric Storage Water Heaters

Energy Efficiency Level (EF)	Average Energy Consumption (kWh/yr)		
	Small-Volume	Large-Volume	All
0.90 (baseline)	2,502	3,660	2,604
0.91	2,473	3,565	2,569
0.92	2,439	3,534	2,535
0.93	2,421	3,485	2,515
0.94	2,377	3,397	2,467
0.95	2,345	3,331	2,431
2.00	1,348	1,927	1,399
2.35	1,172	1,677	1,216

Table 8-I.2.5 and Table 8-I.2.6 show the average installation cost by efficiency level for each subgroup.

Table 8-I.2.5 Average Installation Cost for Gas-Fired Storage Water Heaters

Energy Efficiency Level	EF	Average Installation Cost (2009\$)*		
		Small-Volume	Large-Volume	All
0	0.59	\$628	\$670	\$630
1	0.62	\$702	\$740	\$703
2	0.63	\$735	\$766	\$736
3	0.64	\$853	\$876	\$854
4	0.65	\$867	\$884	\$868
5	0.67	\$884	\$904	\$885
6	0.77	\$904	\$921	\$905

*Average installation cost represents the weighted average cost for replacement and new construction applications.

Table 8-I.2.6 Average Installation Cost for Electric Storage Water Heaters

Energy Efficiency Level	EF	Average Installation Cost (2009\$)*		
		Small-Volume	Large-Volume	All
0	0.90	\$283	\$333	\$288
1	0.91	\$306	\$360	\$311
2	0.92	\$318	\$360	\$322
3	0.93	\$325	\$385	\$330
4	0.94	\$345	\$391	\$349
5	0.95	\$345	\$391	\$349
6	2.00	\$534	\$553	\$535
7	2.35	\$537	\$564	\$539

*Average installation cost represents the weighted average cost for replacement and new construction applications.

8-I.2.2 Base Case Energy Efficiency Distribution

Table 8-I.2.7 and Table 8-I.2.8 present the market shares of the energy efficiency levels in the base case for the gas-fired and electric storage water heater product classes by rated volume.

Table 8-I.2.7 Gas-Storage Water Heaters: Base Case Energy Efficiency Market Shares in 2015 by Rated Volume

Energy Efficiency Level	30 Gallon		40 Gallon		50 Gallon		65 Gallon		75 Gallon	
	EF	Market Share (%)	EF	Market Share (%)	EF	Market Share (%)	EF	Market Share (%)	EF	Market Share (%)
Baseline	0.61	92.01%	0.59	63.92%	0.58	57.29%	0.55	58.93%	0.53	41.67%
1	0.63	1.74%	0.62	23.44%	0.60	4.56%	0.58	13.39%	0.56	26.04%
2	0.64	0.00%	0.63	1.60%	0.62	24.09%	0.59	8.04%	0.57	20.83%
3	0.65	0.00%	0.64	4.79%	0.63	7.81%	0.61	13.39%	0.59	0.00%
4	0.66	0.00%	0.65	0.00%	0.65	0.00%	0.63	0.00%	0.61	5.21%
5	0.68	5.25%	0.67	5.25%	0.66	5.25%	0.64	5.25%	0.62	5.25%
6	0.78	1.00%	0.77	1.00%	0.76	1.00%	0.75	1.00%	0.74	1.00%

Table 8-I.2.8 Electric-Storage Water Heaters: Base Case Energy Efficiency Market Shares in 2015 by Rated Volume

Energy Efficiency Level	30 Gallon		40 Gallon		50 Gallon		65 Gallon		80 Gallon		119 Gallon	
	EF	Market Share (%)	EF	Market Share (%)	EF	Market Share (%)	EF	Market Share (%)	EF	Market Share (%)	EF	Market Share (%)
Baseline	0.93	80.16%	0.92	7.31%	0.90	29.80%	0.88	30.23%	0.86	42.59%	0.80	12.67%
1	0.94	0.00%	0.92	51.15%	0.91	16.76%	0.90	8.64%	0.88	0.00%	0.82	25.33%
2	0.94	0.00%	0.93	0.00%	0.92	11.18%	0.90	8.64%	0.89	0.00%	0.83	12.67%
3	0.94	11.88%	0.93	23.75%	0.93	26.08%	0.91	34.55%	0.90	26.21%	0.84	6.33%
4	0.95	0.00%	0.94	7.31%	0.94	7.45%	0.93	4.32%	0.92	19.66%	0.85	38.00%
5	0.95	2.97%	0.95	5.48%	0.95	3.73%	0.94	8.64%	0.94	6.55%	0.86	0.00%
6	2.02	4.00%	2.01	4.00%	2.00	4.00%	1.98	4.00%	1.97	4.00%	1.92	4.00%
7	2.37	1.00%	2.36	1.00%	2.35	1.00%	2.33	1.00%	2.32	1.00%	2.27	1.00%

8-I.3 RESULTS

Table 8-I.3.1 through Table 8-I.3.4 present the LCC and PBP results for each of the small- and large-volume subgroups. Refer to chapter 8 for an overview of the results categories. The efficiency levels that correspond to TSL 5 are highlighted in bold font.

Table 8-I.3.1 Gas-Fired Storage Water Heaters (Small-Volume): LCC and PBP Results

Efficiency Level ID	Energy Factor	Life-Cycle Cost (2009\$)			Life-Cycle Cost Savings				Payback Period (years)	
		Average Installed Price	Average Lifetime Operating Cost	Average LCC	Average Savings (2009\$)	Households with			Median	Average
						Net Cost	No Impact	Net Benefit		
Baseline	0.59	\$1,072	\$2,440	\$3,512						
1	0.62	\$1,164	\$2,327	\$3,491	\$15	26%	34%	40%	2.0	17.2
2	0.63	\$1,238	\$2,262	\$3,499	\$6	33%	22%	46%	4.5	18.6
3	0.64	\$1,553	\$2,258	\$3,811	-\$271	73%	11%	16%	35.7	57.5
4	0.65	\$1,585	\$2,193	\$3,779	-\$241	71%	6%	23%	26.5	40.1
5	0.67	\$1,650	\$2,111	\$3,761	-\$224	71%	6%	23%	21.8	27.5
6	0.77	\$1,886	\$1,857	\$3,743	-\$206	71%	1%	28%	15.9	17.0

Table 8-I.3.2 Gas-Fired Storage Water Heaters (Large-Volume): LCC and PBP Results

Efficiency Level ID	Energy Factor	Life-Cycle Cost (2009\$)			Life-Cycle Cost Savings				Payback Period (years)	
		Average Installed Price	Average Lifetime Operating Cost	Average LCC	Average Savings (2009\$)	Households with			Median	Average
						Net Cost	No Impact	Net Benefit		
Baseline	0.59	\$1,261	\$3,297	\$4,558						
1	0.62	\$1,355	\$3,117	\$4,472	\$19	8%	79%	13%	1.6	7.1
2	0.63	\$1,418	\$3,062	\$4,480	\$18	19%	40%	41%	4.5	17.7
3	0.64	\$1,714	\$2,991	\$4,705	-\$147	57%	27%	16%	26.4	42.8
4	0.65	\$1,745	\$2,889	\$4,633	-\$83	52%	11%	36%	14.1	19.9
5	0.67	\$1,810	\$2,804	\$4,614	-\$65	58%	5%	37%	13.2	16.7
6	0.77	\$2,066	\$2,404	\$4,470	\$77	49%	2%	49%	9.8	10.3

Table 8-I.3.3 Electric Storage Water Heaters (Small-Volume): LCC and PBP Results

Efficiency Level ID	Energy Factor	Life-Cycle Cost (2009\$)			Life-Cycle Cost Savings				Payback Period (years)	
		Average Installed Price	Average Lifetime Operating Cost	Average LCC	Average Savings (2009\$)	Households with			Median	Average
						Net Cost	No Impact	Net Benefit		
Baseline	0.90	\$554	\$2,604	\$3,157						
1	0.91	\$585	\$2,573	\$3,158	-\$2	7%	68%	25%	3.8	12.4
2	0.92	\$607	\$2,538	\$3,145	\$3	12%	42%	46%	4.0	10.5
3	0.93	\$616	\$2,520	\$3,136	\$9	13%	38%	49%	4.0	10.3
4	0.94	\$657	\$2,474	\$3,131	\$13	23%	15%	62%	5.2	9.6
5	0.95	\$693	\$2,440	\$3,134	\$10	34%	9%	57%	6.9	10.3
6	2.00	\$1,562	\$1,515	\$3,077	\$62	52%	5%	43%	9.8	27.9
7	2.35	\$1,687	\$1,333	\$3,020	\$118	52%	1%	47%	9.4	21.2

Table 8-I.3.4 Electric Storage Water Heaters (Large-Volume): LCC and PBP Results

Efficiency Level ID	Energy Factor	Life-Cycle Cost (2009\$)			Life-Cycle Cost Savings				Payback Period (years)	
		Average Installed Price	Average Lifetime Operating Cost	Average LCC	Average Savings (2009\$)	Households with			Median	Average
						Net Cost	No Impact	Net Benefit		
Baseline	0.90	\$729	\$3,742	\$4,471						
1	0.91	\$778	\$3,647	\$4,424	\$15	5%	67%	28%	3.2	5.5
2	0.92	\$786	\$3,616	\$4,402	\$24	4%	63%	33%	3.0	4.7
3	0.93	\$820	\$3,566	\$4,386	\$31	6%	57%	37%	3.7	5.6
4	0.94	\$852	\$3,477	\$4,330	\$72	6%	28%	65%	3.3	4.5
5	0.95	\$889	\$3,410	\$4,299	\$98	9%	13%	78%	4.3	5.2
6	2.00	\$1,703	\$2,046	\$3,749	\$626	26%	6%	68%	6.0	8.5
7	2.35	\$1,864	\$1,793	\$3,657	\$717	26%	1%	72%	6.3	8.2

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